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ABSTRACT

This report describes MODIA (a Method of Designing Instructional Alternatives), and assesses its utility for planning instruction. MODIA is a computer-based interactive program that helps planners construct a blueprint of instruction, analyze the operation of the instruction, and estimate its cost. It was developed for the Air Force Air Training Command (ATC) and incorporates three programs--the user interface, resources utilization model, and a cost model. Evaluation in the first phase measured cost effectiveness while the second evaluation phase assessed MODIA's utility to local managers, application procedures for Keesler Air Force Base, and the use of the cost model alone. ATC's evaluation of MODIA showed that training managers perceive themselves to be so constrained by policy that they do not take advantage of the opportunities for improved design that MODIA provides. It was also concluded that MODIA's potential can be realized only if it is used by policy-making organizations, with assistance from the operating level. (Author/RAO)

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AN ASSESSMENT OF MODIA--A COMPUTER-BASED SYSTEM FOR PLANNING INSTRUCTION

Polly Carpenter-Huffman

March 1979

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PREFACE AND ACKNOWLEDGMENTS

This paper has been prepared for presentation at the American Educational Research Convention in San Francisco on April 9, 1979. It is one of several papers in the session on computer-based planning and development of instruction.

I wish to express my thanks to my Rand colleagues, Brent Bradley and Ronald Hess, for their useful comments on the draft of this paper.

SUMMARY

This paper describes MODIA (a Method Of Designing Instructional Alternatives), and assesses its utility for planning instruction. MODIA is a computer-based system that helps planners construct a blueprint of instruction, analyze the operation of the instruction, and estimate its cost. Although MODIA was developed for the Air Force Air Training Command (ATC), it is applicable to planning for virtually any situation where instruction reaches large numbers of students or involves scarce or expensive resources, such as undergraduate education, professional education, vocational education, and military training.

MODIA was designed to be used at the operating level in ATC's technical schools because the experience and knowledge needed for course planning is found only at this level and because it seemed more likely that changed operating procedures would be accepted if training managers were actively involved in constructing them. ATC's evaluation of MODIA showed, however, that training managers perceive themselves to be so constrained by policy that they do not take advantage of the opportunities for improved design that MODIA provides. The author concludes that MODIA's potential can be realized only if it is used by policy-making organizations, with assistance from the operating level.

I. INTRODUCTION

In this paper I discuss MODIA, (a Method Of Designing Instructional Alternatives), a computer-based system for planning instruction.[1] MODIA's purpose is to improve training effectiveness or efficiency by stimulating planners to consider and "try out" a variety of designs for instruction before any of them is chosen for implementation. Thus, the emphasis in the acronym is on "alternatives" because encouraging the production of alternatives is MODIA's most important feature.

MODIA was designed to be used by training managers at the operating level in Air Training Command's (ATC's) technical schools. The experience and knowledge of subject matter and students required for design of effective instruction are found only at this level. MODIA requires these inputs because it does not incorporate predictions of the teaching effectiveness of particular approaches to instruction. In addition, I believed that instructors and training managers at the operating level would be more likely to support improved approaches to instruction if they had active roles in designing them.

I begin by describing the types of subject matter, students, and schools and the scale of teaching activity for which MODIA is appropriate. Next I discuss deficiencies in the process of planning instruction that MODIA was designed to alleviate, following this with a description of what MODIA does and what it is, and an example of its

[1] The MODIA system is described in Carpenter-Huffman (1977 a & b), Carpenter-Huffman, Fujisaki, and Pyles (1977 & 1978), Gallegos (1977), and Hess and Kantar (1977).

application by planners in the U.S. Air Force Air Training Command (ATC). The paper concludes with a summary of the findings of ATC's evaluation of MODIA and discusses the implications of those findings.

II. MODIA'S APPLICABILITY

Rand constructed MODIA for ATC, which offers courses dealing with a wide variety of subject matter -- ranging from personnel management to airframe repair -- to a diverse student population including officers and enlisted persons. Thus, MODIA is not limited to particular types of subject matter or students.

Most planning of instruction is carried out by classroom teachers who often prepare for only a few days or a few weeks in advance. Application of MODIA to such planning is inappropriate because of the small number of options available in conventional classroom situations, because of the small set of resources involved, and because of the short planning horizon.

Wherever instruction reaches large numbers of students or involves scarce or expensive resources, however, application of MODIA may be practical. Situations of this kind arise in undergraduate education, professional education, vocational education, and military training.

The current version of MODIA incorporates a feature that has been tailored for ATC, for which it was developed. This is a model of training cost that reflects ATC's resource management policies, as any useful cost model must do. Although the cost model is a key feature of MODIA, MODIA can be used without exercising it. Hence, the cost model limits MODIA's applicability to the extent that the user wants to include cost in planning. In addition, new cost models tailored to

other situations can be developed for a small fraction of the total cost of developing MODIA.

III. BARRIERS TO THE DESIGN OF EFFECTIVE INSTRUCTION

In spite of the pressures on most schools to adopt new instructional techniques and technologies over the past decade, most instruction continues in traditional patterns. Even though the military services have been at the forefront of many of these developments, most military training also continues to operate in conventional ways.

Innovations tend to be promoted from outside of the schools -- by the research community, for example. Moreover, each innovation has tended to be pushed as the single, universal solution to deficiencies in instruction. In ATC, programmed instruction, instructional television, criterion-referenced objectives, and computer-managed instruction have been touted in sequence.

Planners, many of whom have observed the parade of innovations for a number of years, are skeptical about the utility of this or that "improvement" in application to the instruction with which they are concerned. In addition, even experienced planners are generally unaware of the variety of techniques and technologies available.

Even when special pains are taken to apply some new technique to an existing course, unforeseen effects may obviate the utility of the application. In the early days of self-paced instruction, for example, course managers were dismayed when student progress halted at pieces of training equipment that had been purchased to accommodate students grouped into classes. They had not foreseen that this equipment would be insufficient for each student as he arrived at his own time.

Small disasters of this kind make managers of instruction wary of rushing to apply the latest fad.

More commonly, planners faced with a teaching innovation will simply tack it on to regular instruction rather than change the teaching process in any fundamental way. The result is usually smoothly running but ineffective or inefficient teaching. Instructional television is a case in point. Rarely is it used for more than "enrichment," that is, as an adjunct to normal instruction. And, where it has been used in the military services in some instances to present normal instruction, the opportunity for reducing instructor cost has not fully been exploited.

Thus, to insure that newly produced instruction will operate smoothly, planners nearly always design it to proceed in the same way as instruction that preceded it. This also permits them to derive requirements for training resources (facilities, equipment, instructors, and student time, for which the Air Force pays) from past practice. Further, because of the high rate of turnover of military personnel, ATC standardizes and disseminates accepted teaching procedures and resource requirements in regulations governing the organization and operation of the schools. (To a lesser extent, the same phenomenon is found in civilian education codes and the like.) Policies of these kinds and the organizational structures formed to implement them stabilize school operations. They also, unfortunately, effectively discourage changes in those operations.

Opportunities for improvements in teaching effectiveness and efficiency arise frequently in ATC. One-third to one-half of the training syllabus is new or revised annually. Yet, as discussed above, these opportunities are rarely fully exploited. Although the resulting instruction may operate smoothly, it is often inefficient and may be less than fully effective.

To this point, I have been talking about problems in planning a single new approach to instruction. These problems obviously pertain to attempts to design and compare alternative approaches during the planning stage. Beyond this, however, almost all planning of instruction is done by hand, and the effort required to produce a single teaching plan effectively deters planners from trying to devise several plans for comparison. For example, a typical course planning cycle in ATC requires several weeks to a month or more.

MODIA was developed to alleviate these problems by providing planners with means to explore ways to improve instruction before making large investments of their own time or the time of their students in any particular approach. In the next two sections I describe what an ideal planning process should consider and how MODIA facilitates such considerations.

IV. DESIRABLE FEATURES OF PLANNING

Figure 1 shows the aspects of instruction that should be considered during planning. On the left side are essential elements of instruction -- subject matter, students, teacher , facilities, media, and other teaching aids. Most planners routinely consider these elements.

Also shown on the left side of the figure are the policies we have discussed that direct the operation of instruction and the management of teaching resources. These policies, which may be explicitly stated or tacitly assumed, strongly affect the instructional process. (An example of such a policy is an upper limit on class size.) Planners should examine these policies for their appropriateness to specific instruction, but rarely do they do so.

In addition, instruction is a dynamic process involving the interactions of these elements and policies, as suggested on the right side of the figure. These interactions, which can become very complex, should also be considered during planning. Planners of medical education, for example, must consider the management of diverse sets of resources. For example, minimums are often specified for faculty teaching loads by type of teaching -- didactic or clinical. Specialized laboratories with fixed maximum and optimum capacities are shared among courses and faculty with different fields of specialization. For clinical education, teams of students and faculty work with patients with various diseases at different stages of care (diagnosis,

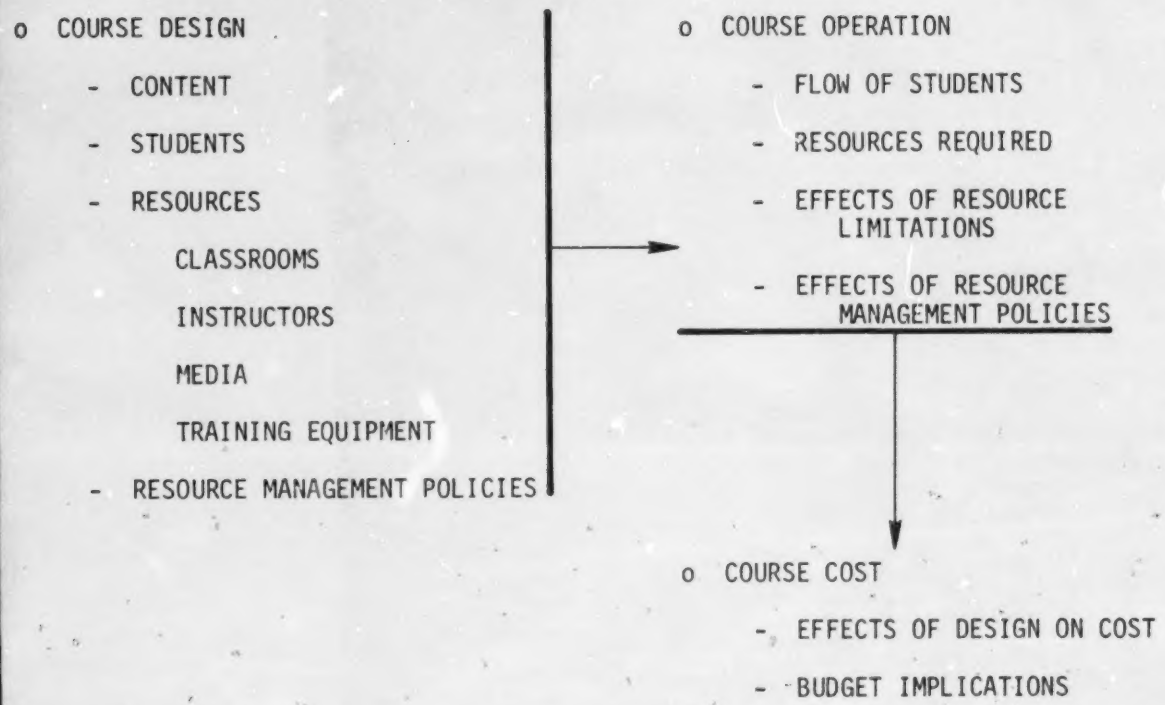

FIG. 1--WHAT SHOULD BE CONSIDERED IN PLANNING INSTRUCTION

therapy, daily care, and discharge). Depending on the severity of the disease and the stage of care, these teams are composed of different numbers of students at different stages in their education. (To avoid compounding these complexities, planners usually eschew policies that would result in increases in the occurrence of random events, such as variable rates of student progress.)

Whenever valuable resources are involved in instruction, planning should also account for the cost of instruction. Even simple models can facilitate consideration of cost during planning. It is especially helpful to be able to trace the cost of teaching to details such as the availability of teaching aids or of teacher time. Beyond this, it is useful to compare the cost of different approaches to instruction, since most organizations are subject to budgetary constraints that emphasize the importance of using teaching resources wisely.

V. HOW MODIA AIDS THE PLANNING OF INSTRUCTION

MODIA is a computer-based tool that is keyed to the essential features of planning just described, including explicit consideration of cost. It incorporates three computer programs -- the User Interface (UI), the Resource Utilization Model (RUM), and the Cost Model (MODCOM). Figure 2 shows these components in relation to the aspects of planning instruction shown in Figure 1.

The UI obtains descriptions of the essential teaching policies and elements from the user, which he enters in response to a sequence of questions from the computer. The program is interactive; that is, the choice of question the computer asks at a given point is influenced by preceding responses from the user.

Once the descriptions of essential elements of instruction are complete, the UI automatically inputs them to the RUM, which simulates the way in which students would proceed through the instruction and the way in which their progress generates requirements for teaching resources. The RUM is a "batch process" program: It receives all of the inputs in a single batch and produces its outputs in batches. The outputs are detailed reports on the operation of instruction including student flow patterns and waiting times as well as resource demand and use.

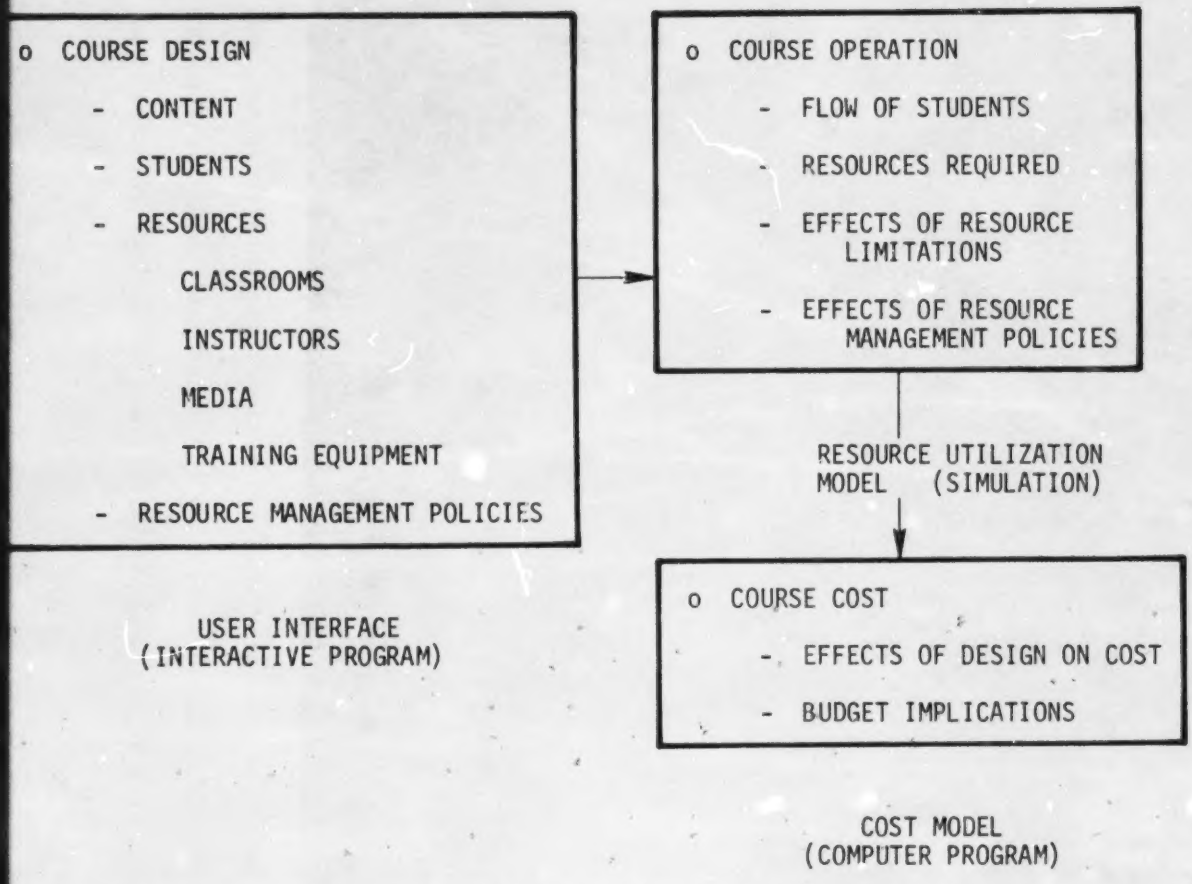

FIG. 2--MODIA COMPONENTS AND THEIR RELATION TO PLANNING CONSIDERATIONS

MODCOM estimates the five-year investment and operating cost associated with a given design. It is also a batch process program, but its inputs are provided by the planner.

MODIA has been designed to be an assistant to planners, encouraging them to consider many alternative designs in the process of planning instruction. MODIA performs time-consuming, tedious, and complex tasks that are performed well by a computer -- to calculate, to verify, to categorize, and to simulate. People are required to perform tasks that are done poorly by a computer -- to create and to evaluate. MODIA assists in these functions by structuring the design process, suggesting alternative choices, and estimating the effects of choices on the operation and cost of instruction.

Thus, people are the most important component of MODIA. As with any tool, MODIA's product is only as good as the user can make it. Skillful application of MODIA requires not only experience with and knowledge of the subject matter and students involved in the instruction, but also thorough familiarity with the system and imagination in its application. Since it is highly unlikely that all of these qualities will be found in a single person, "the planner" will usually be several people, each bringing his own special skills and experience to bear on the planning problem.

Figure 3 shows how MODIA helps this planning team. They begin by studying the Options for Course Design, [1] which provides an overview of the data and information the MODIA will ask for, the range of

[1] Carpenter-Huffman, 1977b.

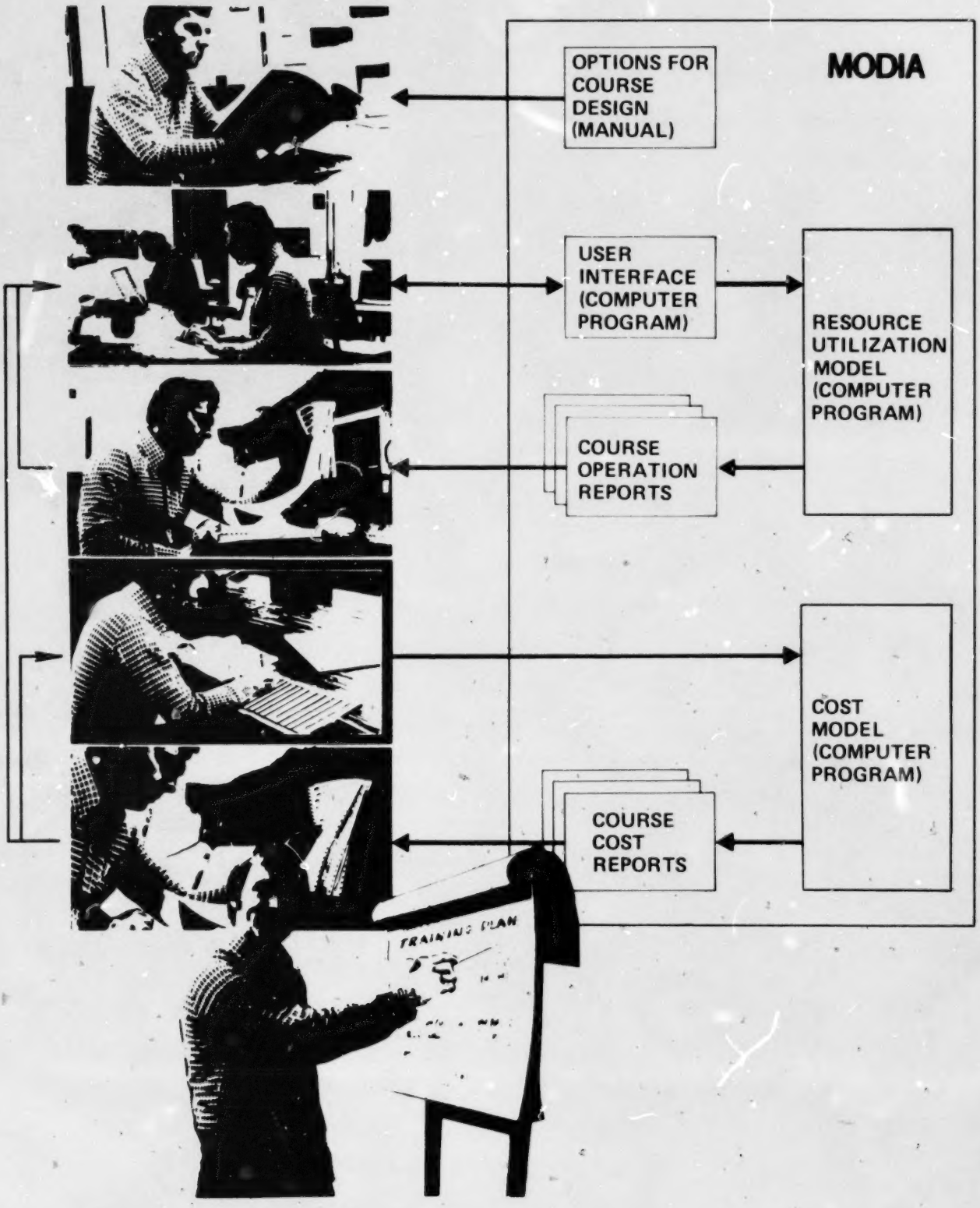

Fig. 3--Interactions between Planners and MODIA.

choices available at each entry point, and the pros and cons of each choice as they affect the operation, cost, or effectiveness of the instruction.

Next, the planners set about synthesizing a blueprint of the instruction with the help of the UI. In this process they may attempt to attain certain educational objectives within the constraints of school policy, the resources on hand, the budget for new resources, types and kinds of teachers available, and types and numbers of students expected. Even so, they have considerable freedom to design the course they believe will best attain the objectives. For example, they can determine the approach to instruction to be used, the sequence in which objectives are to be attained, the media for presenting instruction, and which students will be taught in what ways. Such a process is largely inductive, subjective, and innovative, qualities seldom associated with computers.

During the construction of the blueprint for instruction, the UI checks each decision to insure that there are no internal conflicts among decisions made at different points in the design process and that no part of the design is left out. For example, there must be a strategy for teaching all topics and the resource requirements inplicit in each strategy must have been considered. Thus, the primary roles assigned to the UI are to assure that each design is internally consistent and complete, and to translate each into data that are compatible with the programs that subsequently analyze the design.

To keep the planners informed about the implications of their decisions during the construction of the design, at many intermediate points in the process the UI displays the results to that point. This provides guidance for further decisionmaking or allows the planners to recycle through part or all of the process if they are dissatisfied with the results to that point.

Once the design has been fully specified, the RUM simulates the process of instruction and produces reports on its operation. At this point, the planners' knowledge of the effectiveness of different teaching methods is augmented by MODIA's analysis of the way the instruction they have designed would operate.

Planners will rarely be satisfied with the results of the first complete exercise of the UI and RUM and will repeat the process several times before they prepare the input required for MODCOM. Once the planning team is satisfied with the operation of instruction, they may wish to use MODCOM to determine its cost or the cost of several alternative designs. They prepare MODCOM inputs manually; some may be derived directly from RUM output and some, such as equipment cost, must be drawn from other sources. MODCOM also contains standard cost and manning factors that planners may wish to use or to override. In addition, MODCOM provides options as to which costs should be included and how they should be computed and supplies outputs in two formats, one relating costs to teaching resources (instructors, students, equipment, etc.) and one to categories in the Air Force program budget.

Evaluation of alternative designs is another subjective process requiring the weighing of various performance measures to select the preferred design. I believe there is no single best way to do this, because different schools or planners have different criteria of excellence. For example, one school may be particularly concerned with the cost of training equipment while another may trade increased cost for greater effectiveness. Therefore, MODIA leaves the weighing of alternatives to the people who use it.

Because the bulk of MODIA resides in computer programs, planners may in a very short time generate a design for instruction and estimates of the resources needed to produce and operate it. More important, computerization encourages users to design and compare alternative plans before the instruction specified by a particular plan is produced and put into operation, often a long and expensive process. Once a baseline design has been constructed, alternatives can be generated in a matter of hours or minutes, depending on the degree to which they depart from the baseline and the richness of the baseline design.

VI. AN APPLICATION OF MODIA TO AN EXISTING COURSE

MODIA has been evaluated in an operational setting at the ATC Technical School at Keesler Air Force Base. Keesler planners used MODIA to help redesign several courses that had recently been revised and were considered to be products of top-flight planning. One of these courses trained enlisted persons to maintain automatic tracking radars; some characteristics of this course are shown in Figure 4. Creation of the baseline design required several days of consultation and data collection.

Also shown on Figure 4 are two alternative designs for the same course; these were constructed in a matter of a few hours. One, whose features are displayed in the second column, achieved a reduction in course cost (including student pay) by decreasing the number of instructors teaching the course. Note, however, that the length of the course increased; this was because at several points students had to wait for instructors to become available. For the second alternative, the Keesler planners made enough resources available to insure unhampered student progress. This reduced course length, but course cost increased because not enough students were being taught for the decreases in student pay to offset the increased pay of the additional instructors.

	CURRENT	MODIA ALTERNATIVES	
		DECREASED COST	DECREASED COURSE LENGTH
COURSE LENGTH (WEEKS)	19	26	17
GRADUATES (1 YEAR)	155	155	155
AVERAGE TIME TO GRADUATE (WEEKS)	20	27	17
INSTRUCTORS (% UTILIZATION)	14 (75%)	12 (78%)	18 (68%)
RADAR SETS (% UTILIZATION)	2 (73%)	1 (78%)	3 (35%)
TOTAL COURSE COST--1ST YEAR	$841,000	$776,000	$1,156,000

FIG. 4--AN EXAMPLE OF PLANNING WITH MODIA, COURSE FOR AUTOMATIC TRACKING RADAR REPAIRMEN

Each of these designs might be preferred in a particular circumstance. For example, the first would be selected if reduced cost were an overriding consideration but would be rejected if the possibility that students would be demotivated by having excessive idle time were of primary concern.

These designs were produced during ATC's evaluation of MODIA. In the next section I describe the results of that evaluation.

VII. ATC'S EVALUATION OF MODIA

ATC evaluated MODIA in two phases. Although the findings of the first phase of the evaluation were positive, ATC felt that several important questions had been left unanswered. These were addressed in the second phase.

THE FIRST EVALUATION PHASE

The first phase of the evaluation was conducted by people at Keesler Technical School during the spring of 1976. The objectives of this evaluation were:

> to determine the validity of the course operation and course cost data (MODIA) generates, to assess its effectiveness as a planning tool, to determine its implementation and potential operating costs, and to determine to which types of formal technical training the system can be applied. (ATC, 1976, p. ii).

The major criterion of planning effectiveness was to be that courses produced with MODIA would be sufficiently less expensive than existing courses to offset any additional cost (of computer time, for example) of using MODIA. Improvements in course operation or effectiveness were not sought.

The evaluators found that the courses simulated by MODIA "had a great deal of fidelity to the actual courses." (ATC, 1976, p. 22). In addition, MODIA helped the course planners design alternatives that were less expensive than the existing courses. Finally, the evaluators found that MODIA can be applied to 80 percent of Keesler's course

design work. Because of this wide applicability, they concluded that when the savings that the evaluation indicated were possible in the courses tested were "projected to the population of courses to which MODIA can be applied" they would outweigh MODIA's operational cost. (ATC, 1976, p. 32).

Given these results, one wonders why the evaluators did not recommend adoption of MODIA. They offered two explanations: 1) not enough data were gathered during the evaluation to support a Data Automation Requirement, a formal document needed to set the implementation machinery in motion, and 2) the evaluation did not determine how school policies and objectives would be meshed with MODIA planning, at what level the MODIA products would be used in decision making, or what organizational configuration and operating procedures would be needed to support MODIA planning. The evaluators recommended a follow-on evaluation to resolve these issues.

Two other results of the evaluation, which were not emphasized in the report, presaged the results of the second phase. One was the participants' failure to take full advantage of MODIA for improving the planning process. Such improvements would be MODIA's most important contribution over the long run. People involved in the test believed that MODIA had the potential to make such improvements. They pointed out, for example, that construction of the baseline course and alternatives required about one-fourth of the time needed to construct one course plan by hand, and they felt that therefore MODIA could stimulate more thorough and innovative approaches to course design and

thus make possible the creation of more cost effective courses. (ATC, 1976, p. ii).

The alternatives Keesler actually designed, however, did not begin to make use of MODIA's options. They were rather, marginal changes to careful simulations of existing courses. Thus, the Keesler planners were unwilling to break out of existing ATC policy.

The other finding was related to the foregoing. It had to do with incentives for local training managers to design courses with an eye to reducing cost. The evaluators noted that local training managers are very concerned with reducing the need for new, costly training equipment but that decreased student pay and allowances, decreased support cost, and decreased instructor manning,

> while real in terms of the total Air Force cost for technical training, are considerably less tangible and possibly less meaningful to local planners. ... It is possible that incentives to ... decrease costs in these less tangible areas might be less powerful. (ATC, 1976, p. 29).

At present, training managers perceive that they have control only over the cost of training equipment and that the assignment of students and instructors, whose pay accounts for the bulk of the cost of most Air Force training, is controlled elsewhere. Actually, this is only partly true, since training managers control many of the determinants of instructor and student assignments -- course length and class size, for example. Thus, if local training managers have no incentives to reduce total cost, one of MODIA's most important

features from the Air Force point of view will be of little value to them.

THE SECOND EVALUATION PHASE

The second evaluation, from October 1977 to mid February 1978, was also conducted at Keesler, but this time personnel from the Air Training Command's Technology Applications Center at Lackland Air Force Base designed and carried out the evaluation. Among its objectives were the assessment of MODIA's utility to local managers, the determination of the organizational configuration and operational procedures which might be used in applying MODIA at Keesler, and the examination of the potential utility of using MODCOM by itself.

The procedure to be used in evaluating MODIA's usefulness as a planning and problem-solving tool was

> to present course managers with MODIA products ... and see if they could use (them) to arrive at more cost effective course designs -- while staying within the limits of ATC and Keesler TTC (Technical Training Center) policy directives, manpower limitations and resource constraints. (ATC, 1978, pp. 13 and 14, underlining and parentheses added).

Such a procedure would miss the fundamental problem, namely, that to be most useful, MODIA-assisted planning would have to be carried out in a changed management structure, one that would give planners more responsibility for cost control and more freedom in manipulating resource use. Instead, during the evaluation, MODIA was used to simulate existing courses in as great detail as possible so that course managers could analyze scheduling conflicts, instructor shortages, and

other problems of day-to-day course management. What they wanted was a

> computerized system which would help them with scheduling problems, and/or a system which would optimize the use of certain resources. (ATC, 1978, p. 23).

Not surprisingly, MODIA was unable to simulate the courses in the detail needed to expose all of these problems. Moreover, the simulations merely exposed problems that managers already knew existed. MODIA's inability to simulate complete courses in great detail was the primary source of disaffection among participants in the evaluation. And, as in the first phase, the alternatives they designed represented marginal changes; MODIA's options were not imaginatively used to design courses to minimize existing problems. Finally, as before,

> training management found the costing of course alternatives very interesting but of little value to them in management of course operation or in planning revised courses. (ATC, 1978, p. 34).

The managers believed that the cost information could be used at Headquarters ATC where policy decisions were made that would affect course costs. (ATC, 1978, p. 17).[1]

In general, reactions to MODIA of the 12 training managers and planners were mixed, with greater weight on the negative side. Six felt they would seldom use MODIA if it were adopted; three felt they would sometimes use it; and three believed they would use it often. The

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[1] Headquarters ATC personnel who responded to this suggestion replied that they already had adequate systems for managing course costs. (ATC, 1978, p.37). MODIA is a planning tool, not a system for management of existing courses.

MODIA team of three people who had been thoroughly trained to use the system (and who were also course planners) responded differently -- two would use it often and one, seldom. Despite the generally negative tone of the responses, MODIA had a few strong supporters at the conclusion of the evaluation.

The evaluators recommended against ATC's adoption of MODIA because it does not simulate courses in sufficient detail to solve daily problems of course management. Moreover, if the system were redesigned to satisfy this need it would place excessive demands on the Keesler computer.

Certainly MODIA could be more precisely tailored to ATC concerns. But the underlying reason it failed the ATC evaluation was that innovative planning implies readiness to challenge existing organizations and procedures for managing training. Most of the people who conducted the evaluation and interacted with MODIA did not undertake this approach to planning.

VII. SUMMARY

Is there a future for MODIA? Perhaps, but not at the operating level in ATC or, probably, in most on-going education or training institutions. To realize MODIA's potential as an aid to solving problems in the design of instruction requires users to question and perhaps to change the procedures and organizational structures that govern their daily activities. Several people conducting research on organizations have pointed out that such a process of change is opposed to the process of maintaining an organization. "Organization generates commitment while evaluation (a central process in MODIA) inculcates skepticism." Evaluation is concerned with whether actions lead to the accomplishment of objectives, while organization is concerned with whether actions sustain programs and satisfy clientele. "No one can say for certain that self-evaluating organizations can exist..." (Wildavsky, 1972, p. 510). The MODIA experience seems to reinforce these doubts.

MODIA would be most effectively used in an environment where policies governing instruction may be freely questioned. At the same time, the experience and knowledge of people at the operational level are absolutely essential to insuring realism of input. Thus, MODIA's best use in an institution like ATC would be by a policy-making unit external to but with assistance from the operating level. The highly structured nature of ATC's operations, along with the participation of people from the operating level, might well insure that policy changes

were implemented. In less structured institutions, MODIA might be used at the operating level with the enthusiasm evidenced by a few of the ATC participants involved in the evaluation.

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